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COMPLETE SPECIFICATION

Materials having High Strength and High Resistance to Oxidation at Elevated Temperatures

We, METRO - CUTANIT LIMITED, a British Company, of 160, Piccadilly, London, W.1, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

The demand for materials having a high strength at elevated temperature and which, at the same time, have a high resistance to oxidation, has increased in recent years, especially due to the development of gas turbines. For this purpose a series of high duty steels have been developed consisting mainly of metals of the iron group and chromium with variable additions of molybdenum, tungsten, vanadium, columbium, tantalum, silicon, aluminium, and other metals. It has been proved that these materials are resistant to oxidation, but at elevated temperatures of about 1000° C. they show a low mechanical strength and tend to flow or creep.

It has also been proposed to use ceramic materials for this purpose, but these materials fail due to their low resistance to changes in temperature. According to a further proposal, bodies for high temperature service are formed of molybdenum or tungsten and are protected against oxidation by a coating made of a metallic oxide for instance silimanite. Such materials, however, possess the disadvantage that it is extremely difficult to produce a reliable joint between the metal and the metal oxide.

The present invention has for on object the provision of a material, suitable more especially for use in the manufacture of blades for gas turbines, which even at a temperature of up to 1315° C. is mechnically strong and is at the same time resistant to oxidation.

According to the invention this material consists of one or several carbides of metals having a high melting point bonded but not alloyed with an alloy which is resistant to oxidation at elevated temperature.

The invention makes use of the fact that the carbides of high melting point metals have a great mechanical strength even at very high temperatures. A solid body made of the carbides would, however, not be sufficiently resistant to oxidation nor would the breaking strength be satisfactory. By admixing with such carbides an alloy, such as a nickel-chromium-cobalt alloy, which is known to have a high resistance to heat and to oxidation, a material is obtained which not only has a high mechanical strength, but also shows good resistance to heat and to oxidation. Although it is preferred to use for this purpose alloys which besides being resistant to oxidation have at the same time a high strength at elevated temperature, even alloys with a lower strength at elevated temperature can be used. Therefore, according to this invention, due to the contents of carbides of metals of high melting point, preferably in the form of a carbide skeleton, the strength of an alloy known to have a good heat resistance at elevated temperatures will be considerably increased while, on the other hand, an alloy with good resistance to oxidation but low heat resistance will show also improved mechanical properties at elevated temperatures.

For the carbide phase of the material of this invention, titanium carbide can be used with good results. By the addition of other carbides which together with titanium carbide produce mixed crystals, the strength of the carbide skeleton can be increased and wetting with the oxidation resistant alloy can be improved.

Carbides of the following metals may be used for this purpose: molybdenum, tungsten, zirconium, vanadium, columbium, tantalum, hafnium and chromium.

It has proved to be preferable to mix in such a ratio that the titanium carbide should be more than 80% of the total carbide contents of the finished material.

Preferably the contents of the oxidation resistant alloy should be between 15—40% of the total. The following heat and oxidation resistant alloys are examples of alloys which have been found to be suitable:—

(1)
0.1— 0.4% C
0.5— 1.5% Mn
0.5— 1.0% Si
15.0—20.0% Cr
10.0—25.0% Ni
0.5— 2.0% Mo
1.0— 2.0% W
0.5— 4.0% Cb
0.0— 0.5% Ti
Balance iron

(2)
0.05— 0.5% C
0.5 — 1.0% Mn
0.4 — 0.7% Si
15.0 —25.0% Cr
20.0 —40.0% Ni
20.0 —45.0% Co
3.0 — 4.0% Mo
3.0 — 5.0% Cb
0.0 — 2.5% Ti
Balance iron

(3)
0.2 — 0.4 % C
0.2 — 0.4 % Mn
0.15— 0.25% Si
25.0 —30.0 % Cr
60.0 —65.0 % Co
4.0 — 5.0 % Mo
Balance iron

(4)
0.4— 0.5% C
0.5— 1.0% Mn
0.5— 1.0% Si
15.0—30.0% Cr
5.0% Mo
7.0% W
Balance iron

(5)
25.0—35.0% Cr
3.0— 6.0% Al
0.2— 0.5% Si
Balance iron

(6)
1.0— 1.5% C
0.5— 1.5% Si
15.0—20.0% W
20.0—30.0% Cr
Balance Cobalt

The selection of the heat and oxidation resistant alloy depends mainly on the required properties of the finished material. For instance, the alloys (1), (2), (3), (4) and (6) show between 800 and 1000° C. a considerable heat and oxidation resistance. The material produced according to this invention by using one of these alloys will have, however, a still higher heat strength. Due to the high heat strength of the carbide skeleton it is possible to use an alloy like that of example (5), which is resistant to oxidation up to 1300° C., but has however only a low heat strength.

The preparation of the material is effected in such a way that by sintering the carbides a skeleton body can be formed into which the heat and oxidation resistant alloy may be infiltrated. According to the quantity of the alloy to be infiltrated, the skeleton body should be more or less porous. The porosity of the skeleton body is mainly influenced by the pressure used for the compression of its powder components, which preferably should be between approximately 0.5—4 t/cm2, while the sintering temperature, which can be between 1100—2500°, influences in the first instance the mechanical properties of the material.

For the production of the improved material the carbides may however be mixed with the heat and oxidation resistant alloy in powder form and pressed and sintered. In this latter case it is advisable to perform after the preliminary sintering a hot pressing operation and if required, also a prolonged subsequent sintering, so that a firm carbide skeleton is produced in the sintered body. As to the subsequent sintering, a time from about 5 to 50 hours may be required, while the temperature varies generally between 1300 and 1500° C.

The improved material is particularly suitable for machine parts which are exposed to high temperatures; it can be used, however, with equal success in all cases where a material is required which at temperatures of over 1000° C. shows great mechanical strength and a satisfactory resistance to oxidation.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A material, more especially for use in the manufacture of blades for gas turbines, having a high strength at elevated temperature and a high resistance to oxidation consisting of one or several carbides of metals having a high melting point bonded but not alloyed with an alloy which is resistant to oxidation at elevated temperature.

2. A material as claimed in claim 1, in which the carbide phase consists of titanium carbide.

3. A material as claimed in claim 1, in which the carbide phase contains, besides titanium carbide, one or more carbides of other metals having a high melting point, which form mixed crystals with the titanium carbide.

4. A material as claimed in claim 3, in

which the carbide phase consists of more than 80% titanium carbide.

5. A material as claimed in any preceding claim, in which the quantity of the oxidation resistant alloy amounts to 15—40% of the material.

6. A material as claimed in any preceding claim, in which the oxidation resistant alloy is a nickel chromium cobalt alloy.

7. A material as claimed in any preceding claim, in which the oxidation resistant alloy is constituted as set forth in any of the herein described examples.

8. A process for the production of the material claimed in any preceding claim, in which the carbide or carbides of metals of high melting point are sintered to form a porous skeleton body into which the oxidation resistant alloy is infiltrated.

9. A process for the production of the material claimed in any of claims 1—7, in which the carbide or carbides and the alloy are mixed in powder form and are pressed and sintered.

10. A process for the production of the material claimed in claim 9, in which after a preliminary sintering operation the powder material is subjected to a hot pressing operation followed by a further sintering operation, in order to obtain a firm carbide skeleton in the sintered body.

11. A process for the production of a material having a high strength at elevated temperature and a high resistance to oxidation substantially as herein described.

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